

THE ANNALS AND MAGAZINE OF NATURAL HISTORY.

[SECOND SERIES.]

No. 28. APRIL 1850.

XXII.—*Notes on the Salmon and Bull-trout.*

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IN a short paper on the Salmon, *Salmo salar*, published in the 'Annals and Magazine of Natural History,' vol. xi. p. 409, I have endeavoured, on physiological principles, to establish the fact, that the growth of that valuable fish is not by any means so rapid as it is commonly supposed to be by ichthyologists. Observations having relation to this subject and also to the œconomy of the bull-trout, *Salmo eriox*, have been continued to be made, as suitable occasions presented themselves, up to the present period, on a plan similar to that previously adopted, and I am induced to insist upon the decided advantage which a recourse to physiological phenomena possesses in investigations of this kind over the customary practice of mechanically marking fish as objects of experiment, in consequence of the various sources of error to which the latter mode of proceeding is exposed.

Persons, in their endeavours to determine the rate of growth in fish by marking specimens, too frequently employ subordinate agents to carry their intentions into effect, to whom not only their system of marks is of necessity made known, but the anticipated result is also communicated. Now should it so happen that the agents are dependent upon their employers, or in any respect interested in making the event appear to coincide with their preconceived opinions, the desired object may be easily attained either by secretly marking specimens of a larger size than those which they were instructed and perhaps observed to select for the purpose, and by exhibiting them alone when recaptured, or by adapting the marks to fish subsequently taken, whose dimensions appear to be best suited to promote the end they have in view. Besides, it often happens that all the particulars of the undertaking transpire, and becoming widely circulated, other parties resident in the neighbourhood may apply similar marks to fish of different sizes captured in the same

stream, more especially to kelts, which are comparatively of little value; and that this is not merely a supposititious case, or an imaginary cause of delusion, I can confidently affirm from personal experience. Perforations, and the total or partial excision of any of the fins, may be objected to on account of the modifications which such marks undergo with the growth of the fish, and also on account of the mutilations to which those members are liable from incidental circumstances.

Having thus succinctly directed attention to a few of the objections which may be urged against the manner in which attempts to ascertain the rate of growth in fish by employing artificial marks are generally conducted, I shall revert to the method pursued in my own researches, already referred to at the commencement of this article; namely careful and frequently repeated observations on the gradual loss of the teeth from the vomer, on the order in which they are shed, and on the changes known to take place in the figure of the caudal fin.

The usual number of teeth on the tongue of the salmon-smolt and bull-trout-smolt of six or seven inches in length, when none has been lost, is ten, arranged in a row of five on each side; occasionally I have counted as many as twelve in both species, but ten appears to be the normal number. These teeth are not shed, but most of them are torn away by violence in an irregular manner as the fish advance in growth, so that a want of symmetry in the two rows is conspicuous in much the greater number of individuals. I may remark that such is the case also in every particular with the teeth on the tongue of the common trout, *Salmo fario*.

The teeth on the vomer of the salmon-smolt and bull-trout-smolt commonly exceed twenty (in numerous instances I have noticed twenty-four), a fact which the minute inspection of the heads of both species, after having been placed in nests of the great wood-ant, *Formica rufa*, and subjected to the anatomical process so admirably effected by that industrious insect, fully confirms. Unlike the teeth on the tongue, those on the vomer are shed gradually, commencing at the posterior part and disappearing in nearly regular succession as the fish increase in size; consequently, the loss of teeth from the vomer, taken in conjunction with the form of the tail and the growth of these species, affords to experienced observers a sufficiently exact criterion for determining their relative ages within certain limits.

Smolts of the salmon and bull-trout have the caudal fin much forked; but a progressive alteration in the shape of this organ is effected by the more rapid elongation of its central rays as the fish advance in growth, till, on the acquirement of its perfect development, the posterior margin becomes straight in the

salmon and actually curved outwards in the bull-trout, thus supplying the means of forming a comparative estimate of the ages of both species.

In accordance with what is here stated, I find that specimens weighing from half a pound to a pound and a half have the caudal fin more or less forked, and the vomer well supplied with teeth except at its posterior part, from which some are lost invariably. Specimens weighing from two to five pounds have the posterior margin of the caudal fin either moderately forked, nearly straight, or curved outwards, according to their size and species, and usually have from three to seven or eight teeth on the anterior part of the vomer, the number, after making a suitable allowance for differences in condition, being almost always inversely as the weight; and individuals of large dimensions constantly have the posterior margin of the caudal fin straight or conspicuously curved outwards, and retain one or two teeth only at the anterior extremity of the vomer, or are even without any.

Young salmon and bull-trout weighing from about half a pound to a pound ascend the river Conway during the month of August in much greater numbers than at any other period of the year, and as many of them are infested with that marine parasite the *Caligus curtus* of Müller in various stages of growth, there can be no doubt that they have very recently quitted the salt water. These fish, which from oft-repeated examinations of numerous individuals are found to have the tail forked in a greater or less degree, and uniformly to have lost some teeth from the posterior part of the vomer, though its anterior part is still amply provided with them, I feel thoroughly convinced are identical with smolts of both species which descended the same river in the preceding spring, having then the full complement of teeth on the vomer; for salmon and bull-trout of smaller dimensions do not at any time come up the Conway from the sea, as may be ascertained by actual inspection in calm bright weather, when the water is low and clear and the shoals of fish can be distinctly seen; and if further proof be required, it is abundantly supplied by the conclusive evidence obtained from the large number of specimens taken annually. It is true that I have occasionally procured salmon and bull-trout in the months of March and April which have weighed six ounces only, but they have always been males which had milted or females which had deposited their ova and were out of condition, or what in Scotland are denominated kelts.

I shall here introduce to notice a few examples illustrative of the loss in weight which salmon and bull-trout undergo by the act of spawning.

On the 12th of November 1844, a salmon was captured weighing fifteen pounds, the weight of the lobes of roe, which contained a large quantity of ova in an advanced state of development, being two pounds and three-quarters.

A salmon captured on the 13th of November 1844 weighed seven pounds and a half, and the weight of the lobes of roe, which comprised ova almost in a fit state to be deposited, was two pounds.

A bull-trout taken on the 18th of November 1844 weighed five pounds and a half, the weight of the lobes of roe, which contained ova in an advanced state of development, being one pound and a quarter.

On the 11th of October 1847, a bull-trout weighing half a pound was captured, whose lobes of roe, comprising ova nearly ready for deposition, weighed two ounces.

A salmon weighing fifteen pounds and a half was taken on the 22nd of October 1847, and the lobes of roe, which contained ova in an advanced state of development, weighed three pounds.

The lobes of roe, comprising highly developed ova, taken from a salmon weighing twenty pounds, which was captured on the 10th of November 1847, weighed three pounds and fourteen ounces.

Took the lobes of roe, containing ova on the point of being deposited, from a salmon weighing sixteen pounds, which was captured on the 26th of November 1847, and found their weight to be four pounds.

From these instances it is apparent that the weight of salmon and bull-trout may be diminished one-fourth by the emission of their ova alone, the weight of the collapsed ovaries with their included germs being too insignificant to be taken into consideration; and if to this cause of decreased ponderosity be added another, namely deterioration in condition during the sojourn of these species in fresh water, the absolute loss in weight may be estimated at one-third or more, a circumstance which ought on no account to be overlooked in attempts to determine their rate of growth by marking individuals; and this remark applies with peculiar force when the subjects selected for experiment are kelts, as, unfortunately, it is too commonly the practice to omit measurement altogether on such occasions and merely to give a statement of weight, which, unaccompanied by other data, is evidently insufficient to decide the point in question.

In drawing up this paper I have purposely avoided applying the Scotch term *grilse* to young salmon which have not spawned, as I entertain the opinion that few appellations employed by ichthyologists have been more abused or have led to greater confusion and misapprehension than this.

It appears then, from the physiological facts detailed above, that the growth of the salmon and bull-trout during their first visit to the sea is much less rapid than it is commonly supposed to be; and as in the shoals of these species, which are more abundant in the Conway than any of the other migratory *Salmonidæ*, fish may be observed presenting every gradation of size from the least to the greatest, it is reasonable to infer that their rate of growth is not accelerated materially at any subsequent period of their existence, especially as individuals of large dimensions are found to be very disproportionate numerically to those of a small or even of an average size.

By the cautious inspection of salmon and bull-trout in one of the tributaries of the Conway running through my father's land, up which, when swollen with rain in the months of October and November, they ascend for the purpose of depositing their spawn, and by the frequent examination of their progeny in different seasons of the year, I have satisfied myself that in their œconomy as well as in their rate of growth these species bear a close resemblance to each other. Both remain two years in the fresh water after their extrication from the ovum, during which period, notwithstanding the result of the conclusive experiments so skilfully conducted by Mr. Shaw of Drumlanrig, they are still indiscriminately named parr in this district*, and do not descend to the sea till they have acquired their migratory dress or have been converted into smolts, when they usually measure six or seven inches in length and weigh from an ounce and a half to two ounces. I have ascertained also, by the dissection of very numerous specimens, that the males of the salmon and bull-trout shed their milt before they make their first descent to the sea, but that the females do not spawn till they return from their first visit to the salt water; indeed the ova are so little developed in the month of May, at which time the principal migration seaward takes place, as scarcely to be discerned without the aid of a magnifier.

Among the external characters which serve to distinguish the bull-trout-smolt from the salmon-smolt are a more robust and trout-like figure; a more decided prominence of the row of scales forming the lateral line; a greater number of spots below that line; a yellowish tinge on the lighter-coloured pectoral fins; a bright red tint at the extremity of the adipose fin; and a firmer adhesion of the scales to the skin.

In conclusion, I shall briefly notice a few cases of rapid changes in the colour of fish which have come under my own

* A bull-trout in its second year more nearly resembles a trout than a salmon of the same age.

observation. Trout, suddenly transferred from their natural haunts into wooden, metallic or earthenware vessels supplied with water recently taken from the same stream in which they were captured, speedily assume a lighter hue; and as this change does not appear wholly to depend upon the colour or capacity of the vessels in which they are placed, I am inclined to attribute it primarily to the influence of fear, and in this opinion I am the more confirmed from having frequently perceived a similar transition in the hue of salmon soon after they have been hooked by the angler. That this is not the sole occasion of sudden alterations in the colour of fish I readily admit, for I have often disturbed small flounders in the Conway, which on changing their situation and reposing upon objects of a different hue from those they had last quitted, soon became accommodated to this circumstance of their novel position by undergoing a modification of shade which harmonized with that of their resting-place and effectually served to conceal them from ordinary observation. Even death, as the disciples of Isaac Walton are well-aware, and as the following anecdote clearly proves, does not immediately put a stop to this chameleon-like transition of tint.

A gentleman of my acquaintance, a proficient in the art of fly-fishing, had taken a young salmon weighing about a pound and a half, which, in consequence of having been a long time in the fresh water, had lost its brilliancy and had acquired a very dark aspect; this fish one of my children requested to be permitted to carry, so after having inserted the longer and smaller end of a slender forked twig under one of the gill-covers and drawn it through the mouth till the prize was retained in the angle formed by the fork, I gave it to the boy, who held it suspended with the tail downwards. After the lapse of several minutes, perceiving that the fish had lost all its blackness and had become perfectly bright, I directed the attention of my acquaintance to it, who could scarcely be persuaded that it was the same which he had captured a short time before, but supposed that I had secretly substituted another for it; however, the speedy resumption of its former dark complexion, which underwent no further mutation, completely convinced him of its identity.

I shall not attempt to offer any explanation of the remarkable physiological phenomenon here recorded; but, apart from the mysterious operation of psychological agency, its cause must undoubtedly be sought for in the organization of the rete mucosum.